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INVESTIGATION OF TECHNOLOGICAL LUBRICANTS BASED ON SALT MIXTURES FOR HOT ROLLING OF TUBES

By

G. A. Rodionova, Ya. S. Finkel'shteyn, et al.

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
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П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

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INVESTIGATION OF TECHNOLOGICAL LUBRICANTS BASED ON SALT MIXTURES FOR HOT ROLLING OF TUBES

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During rolling of tubes on a continuous mill with a long mandrel, lubricant working conditions are extraordinarily severe; the special requirements faced by lubricants give rise to additional obstacles during the selection of constituent components.

The assignment of a lubricant during hot rolling on a continuous mill with a long mandrel boils down to the reduction of the coefficient of friction, decreasing the resistance of the metal to plastic deformation, elimination of sticking of processed metal, and decreasing tool wear.

One of the basic requirements for the lubricant is suitability to the temperature conditions during rolling.

The approximate temperature conditions of the work of a lubricant during continuous rolling of tubes are presented schematically in Fig. 1. Temperature is plotted along the axis of ordinates and the time from moment of feeding the mandrel into the case, along the axis of abscissas (in logarithmic scale).

The case which is sent to the continuous mill has a temperature of 1130-1150°. After rolling the temperature of the tube comprises

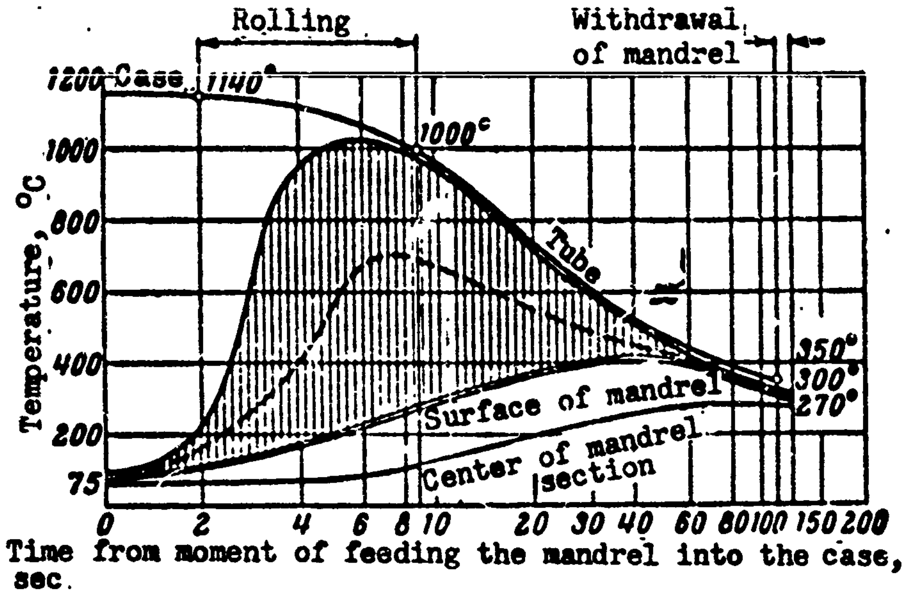

Fig. 1. Approximate temperature conditions of the work of a lubricant during continuous rolling of tubes.

800-1000°, and in individual sections 500-600°. Before extraction of the tube the temperature is lowered to 300-400°. The temperature of the mandrel before feeding into the case is within the limits 80-90°. During rolling the temperature of the surface of the mandrel is increased and at extraction attains 270-290°.

During rolling the lubricant is simultaneously in contact with the deformed metal of the tube, having a high temperature, and the surface of the mandrel, having a relatively low temperature.

The drop of temperatures, constituting 1050-1060° in the initial period of rolling, decreases to 30-110° at the moment of extraction.

The average temperature of the layer of lubricant depends on its thermal conductivity: when the thermal conductivity of the lubricant is equal to that of the metal of the tube and the mandrel, the average temperature of the lubricant will constitute an arithmetic mean between the temperatures of the tube and the mandrel. When the thermal conductivity of the lubricant is higher than that of the metal, the temperature of the lubricant will approach the higher temperature of the

tube.

A lubricant applied during continuous rolling of tubes can be, at the initial moment of rolling, at temperatures within the limits 80-200°, with a mean value of about 150°, and at the last moment of rolling it can be at temperatures within the limits 300-830° with a value of about 650°. The highest temperature of separate sections of the lubricant during rolling can attain 950°. After rolling intense heating of the surface of the center of the mandrel section and cooling of the tube occur. The interval of lubricant temperature is narrowed with a reduction of the average temperature of the lubricant to 300°. Consequently, the lubricant should first of all to have sufficiently high lubricating properties in a wide temperature interval — from 150 to 650° — and should not lose these properties with later cooling to 300°.

Other basic conditions of the work of a lubricant during continuous rolling are high deformations and specific pressures.

Table 1 gives the total pressures on the roller, the average specific pressures, the total deformation over the thickness of the wall, and coefficients of elongation in each stand during rolling of tubes with dimensions of 59 × 3.25-3.5 mm of steel 10 [1].

From Table 1 it is clear that deformation in the third-fourth stands at the peak of the pass over the thickness attains 48-51%, and coefficients of elongation in the second-fourth passes are 1.3-1.7.

During deformations on a continuous mill with use of a lubricant the load on the motor during rolling of 59 × 3.5 mm tubes of steel 10 attains 900-1000 kw, and during rolling of 59 × 40 mm tubes of steel 1Kh18N9T it reaches 1000-1200 kw.

The power of the motor and equipment are calculated for loads of 1427 kw, and exceeding these magnitudes can lead to failure of the mill.

Therefore in the selection of a lubricant one of the basic requirements is the reduction of loads on the motor of the continuous mill.

The rate of flow of metal from first to the last stand increases from 0.45 to 1.80 m/sec, i.e., the degree of the increase in slip comprises 4; if one were to assume that lag and outstripping of the metal with respect to the mandrel are equal, the degree of slip of the metal with respect to the mandrel will constitute not less than 2 in first and last stands.

Besides the enumerated requirements, a lubricant should be technologically effective, i.e., easy to apply on the surface of tool and to wet the metal surface, easily removed from the internal surface of tubes and mandrels, noncorrosive to the equipment and tool or in terms of intercrystallite corrosion of the metal; and it should be economically profitable.

The mechanism of the action of lubricants during hot working of metals has been insufficiently investigated, and till now rational lubricants have not been selected for a number of the most important technological processes [2] (die forging of steel and aluminum alloys, extrusion of metals, pressure molding of steel aluminum, magnesium, and titanium alloys, rolling of tubes on long mandrels).

The most complicated conditions of friction appear during the continuous rolling of tubes on a long mandrel. With this the tube is simultaneously in the seventh-ninth stands of the mill; the speed of the metal is increased from its entrance into the mill to its exit from it by 4-5 times, and the speed of the mandrel is constant over the entire length.

We conducted an investigation on the application of glass as a lubricant during continuous hot rolling of tubes on a long mandrel of the mill STZ.

Table 1. Change in Parameters of the Process of Rolling of Tubes in a Continuous Mill

Parameter of rolling process	Stands of continuous mill						
	first	second	third	fourth	fifth	sixth	seventh
Temperature over the stands, °C. .	1140	1110	1090	1060	1040	1020	1000
Rate of deformation, m/sec	-	-	55	-	-	-	-
Average specific pressures calculation, kg/mm²	-	-	21.5	24	23	20.5	-
Total pressures per experimental data, t . . .	10-20	20-35	45-70	30-55	18-30	12-20	9-16
Speed of tube during exit from stand, m/sec	0.43	0.60	0.99	1.35	1.60	1.80	-
Coefficient of elongation (2, 3) .	1.2-1.5	1.4-1.7	1.3-[illegible]	1.1-1.3	1.1-1.2	1.0-1.2	1.0-1.05
Pressing over thickness of wall at peak of pass, mm.	-	-	1.1	3.9	1.8	0.7	-
%	-	-	51.2	48.2	32.2	16.7	-

Rolling conditions were satisfactory; however, the process of extraction of the mandrel from the tube was hampered. A serious deficiency of glass lubricants is the difficulty of their removal from the internal surface of tubes.

From this it follows that the problem of lubrication during hot working of metals by pressure was still not solved.

The most promising direction for improvement of the technological processes is the investigation of the lubricating properties of mineral lubricants based on eutectic salt mixtures both in pure form and mixed with various fillers.

During pressure treatment of metals in conditions of raised temperatures a graphite-containing lubricant is applied. Therefore, during the investigation of various new lubricants the comparison of lubricating systems.

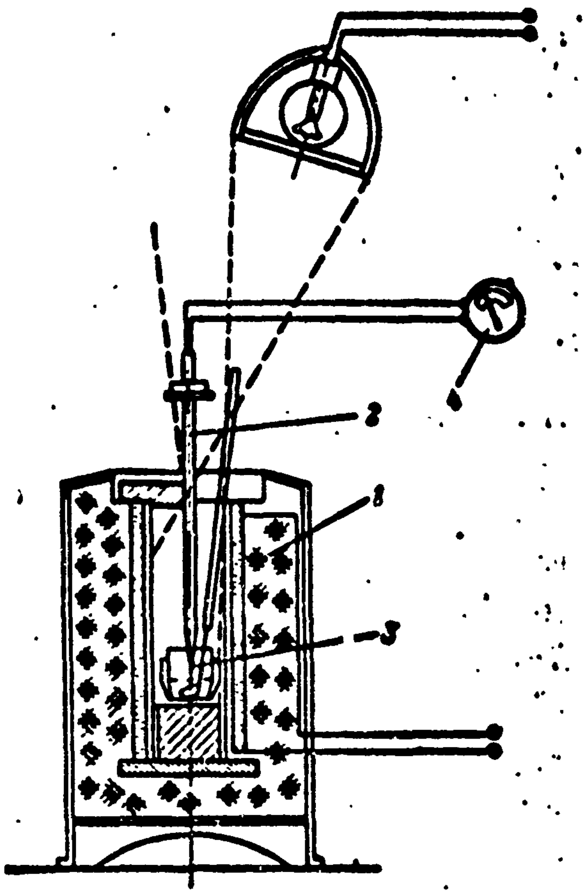

Fig. 2. Diagram of installation for the determination of the melting and crystallization points of salts by the visual-polythermal method: 1 — crucible furnace; 2 — thermocouple; 3 — crucible; 4 — millivoltmeter.

Hygroscopic salt mixtures will form in water viscous systems-hydrous salt syrups with lubricating properties. Salt syrups have been used during the drawing of steel wire. To increase viscosity fillers were introduced in them in the form of oxides of the metals, zinc, cadmium, calcium, [and] lead.

Mechanical fillers in a technological lubricant increase the relative thickness of the layer of lubricant at the places of contact of the working surfaces of metals. The increase in the thickness of the lubricant layer sharply lowers the external friction of metals and increases the surface quality of processed articles [3].

In this work we have set as our goal the search for new forms of technological lubricants, based on salt mixtures, for continuous rolling of tubes.

Optimum lubricants were tested during the rolling of tubes of steel 10 and steel 1Kh18N9T on the STZ continuous mill.

The thermal stability of salt lubricants was determined in the temperature interval 20 to 900°, answering to conditions of deposition of the lubricant and rolling of tubes. The visual-polythermal method of investigation was accepted. The installation, presented schematically in Fig. 2, consisted of an electric crucible furnace of the type TG-1, a KhA [Chromel-Alumel] thermocouple, and an MPP-254 millivoltmeter.

For preparation of the lubricants we used salts classified "chemically pure" or "analytically pure." Salt melts were prepared in porcelain and graphite crucibles. The temperature of the melt was measured by the Chromel-Alumel thermocouple, connected to the millivoltmeter.

During the investigation we established the melting and crystallization points of the lubricant (with the help of the thermocouple), the thermal stability, the wettability of the metallic surface, and (visually) the characteristic of the lubricant film on the metal.

Wettability of the metal by the salt lubricant was determined by the submersion in the melt of a stainless steel rod, cold and heated to 80-200°. All the systems were conditionally divided by melting points into low-temperature (from 20 to 250°), medium-temperature (from 250 to 500°), and high-temperature (from 500 to 800°) systems.

During tests of the medium-temperature lubricants the best technological properties were detected in lubricants based on the salts: 1) zinc chloride, potassium chloride, sodium chloride; 2) lithium chloride, potassium chloride; 3) lithium chloride, magnesium chloride; 4) potassium chloride, magnesium chloride; 5) cadmium chloride potassium chloride, sodium chloride; 6) zinc sulfate, potassium chloride.

These lubricants, with various fillers, were recommended for industrial tests on the STZ continuous mill.

Further tests were conducted with a lubricant consisting of a mixture of the salts potassium chloride, zinc chloride, and sodium

chloride.

The investigation of the system was conducted in three directions: we studied the influence of the quantity of the low-melting component and filler on the melting and crystallization points, and also the change in the state of the system from the degree of dilution.

To establish the optimum quantity of zinc chloride in the lubricant we conducted experiments for the study of the influence of the quantity of the low-melting component on the melting and crystallization temperatures. The content of zinc chloride in the system was varied from 0 to 60% at each 5% with a constant ratio of the other two components at 1:1. The system was prepared in the form of a mechanical mixture of the salts in the crushed state. Investigations were conducted by the visual-polythermal method.

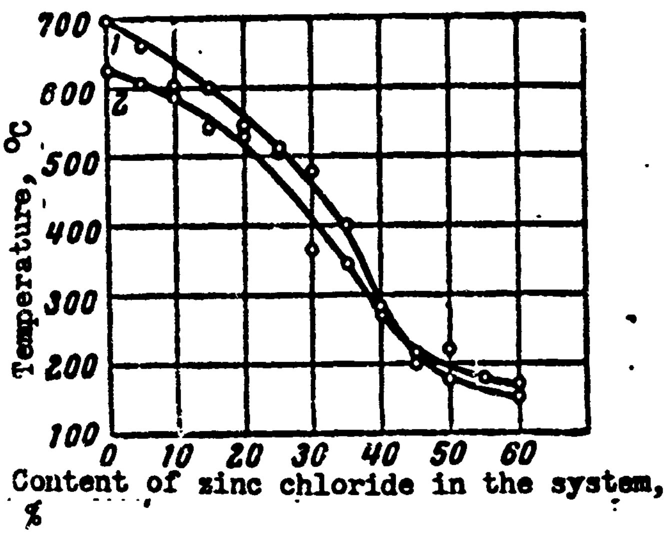

Fig. 3. Dependence of melting and crystallization temperatures of the salt mixture on the quantity of zinc chloride in the system: 1 — curve of melting; 2 — crystallization curve.

Analysis of the data obtained (Fig. 3) shows that with an increase in the quantity of the low-melting component a lowering of melting and crystallization temperatures of the system is observed.

We must note that the presence in the lubricant of the low-melting component in a quantity higher than 40% leads to an increase in the temperature of crystallization as compared to the melting temperature. This phenomenon indicated that during heating to high temperatures strong volatilization of the low-melting component occurs, owing to thermal instability. The system is impoverished of the low-melting

component and during cooling the crystallization temperature is increased.

As a result of the experiments 40% zinc chloride is accepted as the optimum quantity in the system.

Subsequent tests were conducted with a lubricant with a composition of zinc chloride, potassium chloride, and sodium chloride.

A filler — magnesium oxide — was added to the system in quantities of 6, 8, 10, 12, 14, 16, 18% of the weight of the system. The system was diluted with water to the consistency of sour cream and was heated in the furnace. Melting and crystallization temperature were determined by the visual-polythermal method.

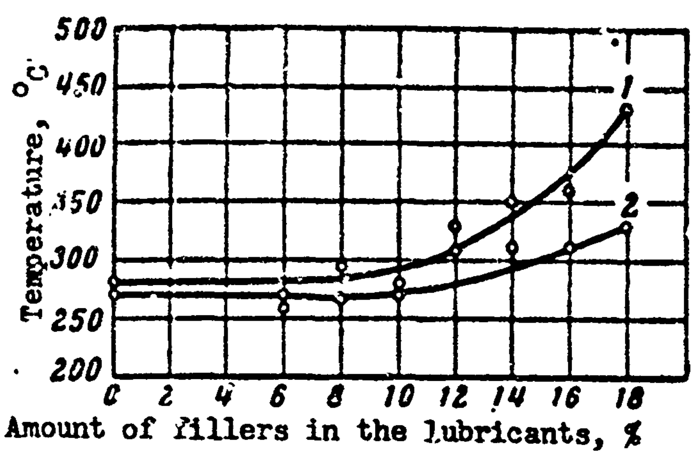

Fig. 4. Dependence of the temperature of melting and crystallization of salt mixutre on the amount of filler in the system: 1 — melting curve; 2 — crystallization curve.

The results of the tests are given in Table 2 and in Fig. 4.

From the experimental data it is clear that the filler — magnesium oxide — insignificantly increases the melting temperature of the system, while practically not affecting the crystallization temperature.

The lubricant can be placed on the mandrel by various methods — submersion of mandrels in the melted salts, atomization of the melt or a dry mixture into the case ahead of the mill, submersion in an aqueous mixture of salts of a definite consistency, and manually, with a brush.

The basic method of applying the lubricant can be considered to

Table 2. Results of Laboratory Investigations of Systems with Various Filler Contents

No. of experiment	Composition of system, %	Temperature, °C of melting practical	Temperature, °C crystallization	Thermal stability up to 1000°	Wettability of surface of metal	Characteristic of film	Conclusion about suitability for production test
1	Zinc chloride — 40 potassium chloride — 30 sodium chloride — 30 magnesium oxide — 6*	270	260	High, does not burn, is evaporated insignificantly, does not smoke	Nonuniform film on surface of steel rod	During cooling the film is chipped	Suitable for test
2	Zinc chloride — 40 potassium chloride — 30 sodium chloride — 30 magnesium oxide — 8*	295	265		Analogous to preceding		
3	Zinc chloride — 40 potassium chloride — 40 sodium chloride — 30 magnesium oxide — 10*	280	270	Analogous to preceding	Uniform homogeneous film on surface of steel rod	Analogous to preceding	
4	Zinc chloride — 40 potassium chloride — 30 sodium chloride — 30 magnesium oxide — 12*	330	310	High, does not burn, is evaporated insignificantly, smokes from 678°	Nonuniform liquid layer on surface of steel rod	Analogous to preceding	
5	Zinc chloride — 40 potassium chloride — 30 sodium chloride — 30 magnesium oxide — 14*	350	310	Analogous to preceding, smokes from 615°	Uniform homogeneous film on surface of steel rod	Analogous to preceding	
6	Zinc chloride — 40 potassium chloride — 30 sodium chloride — 30 magnesium oxide — 16*	360	310	Analogous to preceding, smokes from 630°	Nonuniform film on surface of steel rod	Analogous to preceding	
7	Zinc chloride — 40 potassium chloride — 30 sodium chloride — 30 magnesium oxide — 18*	430	330	Smokes from 660°	Analogous to preceding		

* In percent of weight of system.

be submersion in an aqueous mixture of salts of a determined consistency. The consistency should be such that the lubricant is applied as a uniform layer, holding well on the surface of the mandrel.

In laboratory conditions the selection of the optimum quantity of diluent — water — necessary to produce the needed consistency was conducted by means of the consecutive addition of diluent and the determination (weighting) of the quantity of lubricant applied per unit of surface on a special mandrel by submersion.

The methodology of determining the optimum dilution of the system consisted in the following: a composition of the lubricant was produced on the basis of calculated quantities of salts and filler, after which equal quantities of diluent were added successively from a burette. A rod with a known surface of submersion was dipped into the system. The quantity of lubricant coated on the rod was determined by the difference in the weight of the rod with and without the lubricant. Then formula (1) was used to determine the quantity of lubricant (in g per 1 m^2 of dipped surface):

$$x = \frac{a \cdot 10^4}{b}, \mathrm{g/m^2} \qquad (1)$$

where a is the weight of applied lubricant, g; b is the surface of submersion of rod, cm^2.

Dilution was continued until the quantity of lubricant held on the rod upon dipping in the lubricant corresponded approximately to 200 g/m^2 (the quantity of the lubricant graphite plus mazut on the mandrel).

The result of the experiments showed that:

1) the quantities of water necessary for dilution of the system with magnesium oxide contents of 6, 8, 12, 16 and 18% is practically

the same and equal approximately 27-30%. The viscosity of systems is quickly lowered to a minimum. Upon standing the systems are stratified, which is undesirable;

2) Systems with magnesium oxide contents of 10 and 14% require larger quantities of diluent — 45.5% and 76.7%, respectively. The systems apply on the rod as uniform homogeneous films and hold well, not being stratified after holding for 4-5 days;

3) By using the dilution curves, one can determine the quantity of diluent necessary for the production of any quantity of lubricant on the mandrel (Fig. 5).

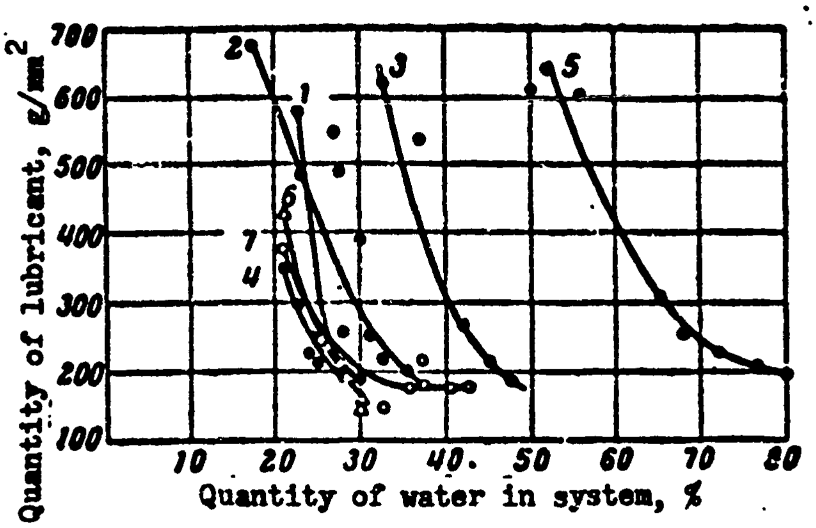

Fig. 5. Dependence of the quantity of lubricant on 1 m^2 of surface on the quantity of filler and content of diluent in the system. Quantity of filler in system: 1 — 6%; 2 — 8%; 3 — 10%; 4 — 12%; 5 — 14%; 6 — 16%; 7 — 18%.

On the basis of the obtained data, 10% is accepted as the optimum quantity of filler, since in this case the system has high melting and crystallization temperatures, is uniform with dilution to the necessary consistency, and is not stratified and does not harden during 4-5 days. The study of the state of this system in time was

conducted by two methods:

1) the optimum quantity of water, 45.5% (of the weight of the salts), was added completely in a prepared mixture of salts. At definite intervals the state of the system was established visually;

2) water was added gradually in the quantity to produce a uniform, conveniently applied consistency. Visual observation of the state of the system and its dilution were produced at determined intervals of time.

On the basis of laboratory investigations:

1) the possibility was shown of obtaining of salt systems with various melting and crystallization temperatures: low-temperature (from 20 to 250°), medium-temperature (from 250 to 500°), and high-temperature (from 500 to 800°);

2) it was established that with an increase in the filler — oxides of metals — the melting and crystallizatiom temperatures remain unchanged until a certain quantity of filler is reached, after which they start to increase;

3) the dependence of the quantity of lubricant (applied per unit of surface of a metallic mandrel by submersion) on the quantity of diluent was found;

4) it was confirmed that the addition of a low-melting component lowers the melting and crystallization temperatures of the system. However, the presence in the lubricant of a low-melting component in a quantity greater than 40% leads to an increase in the crystallization of temperature above the melting temperature;

5) the optimum composition of the lubricant was found: 40% zinc chloride, 30% potassium chloride, 30% sodium chloride, 10% filler

magnesium oxide, 45.5% (of the weight of the entire system) diluent (water).

<u>Industrial tests of the lubricants</u> were conducted on a continuous tube-rolling mill with a long mandrel.

The following problems were set up:

1) to establish the fundamental possibility of the application of salt lubricants during continuous rolling;

2) to estimate the lubricating properties in comparison with a graphite-mazut lubricant;

3) to clarify the role of fillers;

4) to determine the influence of the quantity of applied lubricant and its state (with charging of dry mixture) on the rolling process.

Table 3 gives data characterizing the properties of the tested salt systems.

For preparation of lubricants we used salts with the qualifications chemically pure or analytically pure.

In accordance with the composition, the components of salts and fillers were diluted by water in quantities answering to 200-250 g/m^2 and were thoroughly mixed to consistency of sour cream.

Salts and fillers were precrushed and were sifted through a sieve No. 30 (with the exception of lithium chloride and zinc chloride, since they are strongly hygroscopic). For preparation of lubricant No. 7 the filler — bentonitic clay — was prepared separately from the salts by mixing with water.

Tests were conducted on new mandrels and on mandrels which had been in operation for a short time (3-4 hours).

The new mandrels were rubbed with rags before the application of

Table 3. Results of Experiments, Characterizing the Properties of Salt Systems

No. of lubricant	Composition, %	Melting temperature, °C	Crystallization temperature °C	Quantity of water necessary for dilution, in % weight of salts and filler	Quantity of lubrication applied by dipping per 1 m^2 of metallic surface, g/m^2	State of lubricant during heating to 800°
1	Lithium chloride — 60 potassium chloride — 40 zinc oxide — 10*	340	340	17	281	Viscous thick mass, does not burn, smokes slightly from 590°, no odor
2	Lithium chloride — 60 potassium chloride — 40 calcium oxide — 10*	265	250	17	158	Low-viscosity mass, does not burn, smokes slightly from 700°, no odor
3	Lithium chloride — 60 potassium chloride — 40 magnesium oxide — 10*	340	320	11	-	Viscous mass, smokes weakly, no odor
4	Lithium chloride — 60 potassium chloride — 40 graphite — 16*	340	330	18	-	Viscous, mobile mass, smokes slightly, no odor
5	Lithium chloride — 60 potassium chloride — 40	340	340	15	-	Low-viscosity system, does not burn, smokes from 670°, no odor
6	Zinc chloride — 40 potassium chloride — 30 sodium chloride — 30 magnesium oxide — 10*	280	270	20-30	790	Viscous mass, does not burn, smokes from 755°, no odor
7	Zinc chloride — 40 potassium chloride — 30 sodium chloride — 30 bentonitic clay — 10*	298	280	30	355	Thick, viscous melt, smokes from 575°, no odor

*Quantity of filler is given in % of weight of salts.

the lubricant. Mandrels which had been in operation were washed with kerosene, degreased with lime, and rubbed with rags prior to application of the salt lubricant, in order to remove the residue of graphite-mazut lubricant.

The surfaces of all mandrels were inspected for mechanical defects — pits, notches.

Rolling of tubes of steel 10 was conducted from blanks with the dimensions 90 × 750, 90 × 690, and 90 × 720 mm, and those of steel 20 from blanks of 90 × 683 mm. Blanks were not subjected to preliminary investigation.

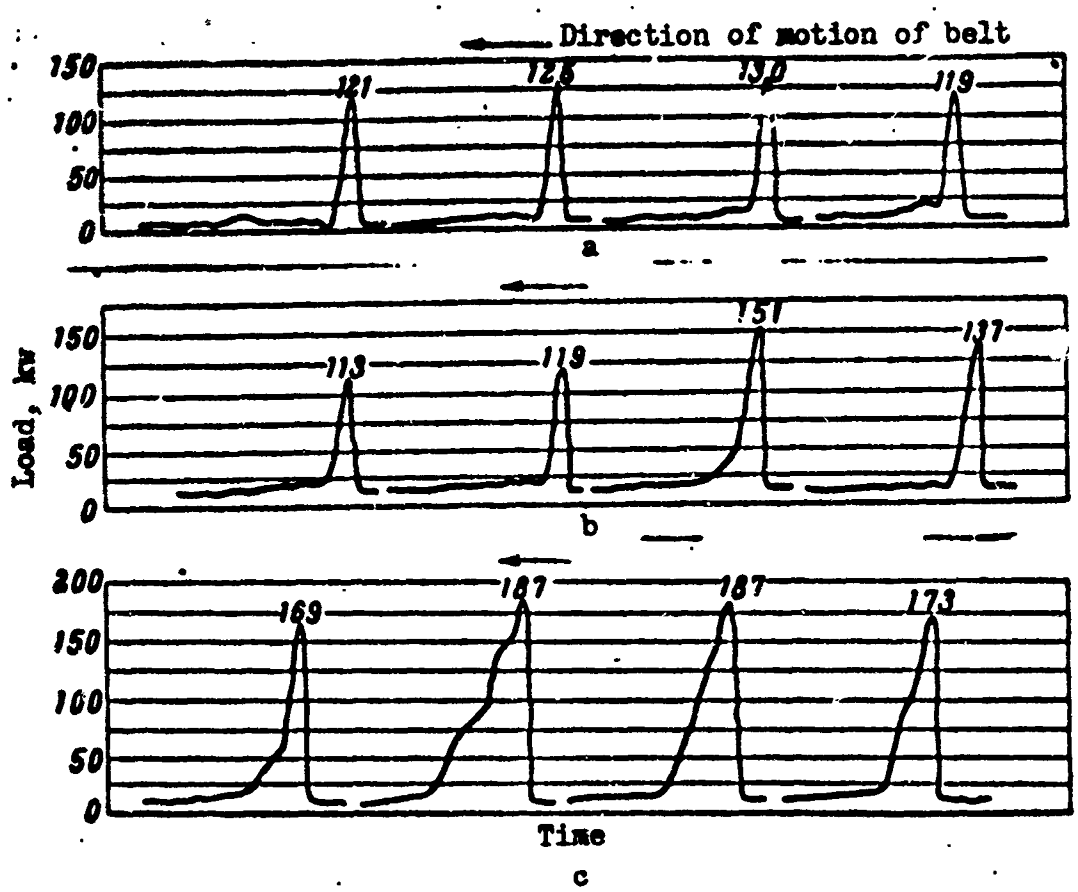

Fig. 6. Loads on the extracter motor: a) lubricant No. 1; b) lubricant No. 2; c) lubricant graphite + mazut.

During rolling of tubes of steel of brand 1Kh18N9T procurements with ϕ85 mm and length of 820 mm were used. Templets 80 mm in

length were selected from two blanks for testing for intercrystallite corrosion by the AM GOST 6032-58 method.

As a result of tests no intercrystallite corrosion was revealed.

Lubricants were applied to the surface of the mandrels manually, with a brush.

Both cold and warm mandrels were moistened satisfactorily.

None of the lubricants dried out, due to the hygroscopicity of the lithium chloride.

Lubricants based on chlorous salts of zinc, potassium, and sodium with fillers (magnesium oxide and bentonitic clay) were coated on as uniform layers.

The wettability by the lubricant worsens on a nondegreased surface.

The test was conducted during the rolling of tubes with dimensions of 57 × 3.5 mm of steel 10, 59 × 3.2 mm of steel 20 and 57 × 5 mm of steel 1Kh18N9T.

During the test the data characterizing the process of rolling were fixed: peak loads on the motor of the continuous mill and that of the extractor temperature at the beginning of the process, temperature of the tube before extraction of the mandrel, the presence of smoke and flame.

The peak loads on the motor of the continuous mill were measured by a wattmeter; the force of extraction, by a self-recording wattmeter; the temperature of the case before rolling, by an optical pyrometer; the temperature of the tube before extraction of the mandrel by a contact thermocouple. The best results in rolling tubes of steel 10 and steel 1Kh18N9T are obtained with lubricant No. 6 (see Table 3).

The rolling of the metal of the tube on the mandrel proceeded

satisfactorily.

The peak loads on the motor of the continuous mill were increased, on the average, by 4% (within tolerable limits).

The withdrawal of mandrels from tubes of steel 10 proceeded analogously to the extraction on graphite-mazut lubricant; for tubes of steel 1Kh18N9T it was somewhat poorer – vibration was observed. The quality of the surface of the mandrels after rolling remained without noticeable change, but traces of corrosion were revealed. No adhesions of metal on the mandrels were detected.

The rolling of tubes of steel 10 on all the rest of the lubricants did not give positive results. The peak loads on the motor of the continuous mill were increased with lubricant No. 1 by 20.6%, No. 2 by 21%, No. 3 by 20%, No. 4 by 9%, No. 5 by 18%, No. 7 [sic] by 25%, and on No. 7 by 36%.

The rolling of a tube on a mandrel with these lubricants proceeded less well than during work with graphite-mazut lubricant.

In the first moment the extraction of the mandrel from the tube occurred jerkily, but then it was smooth. The loads on the motor of the extractor, measured by the self-recording wattmeter, are shown in Fig. 6. The surface of mandrels after rolling was dull, with brown deposits, with traces of corrosion. No adhesions of metal on the mandrel surfaces were found.

Tubes rolled with the experimental lubricants tubes and rolled with graphite-mazut lubricant (for comparison) were inspected and measured along the diameter in two mutually perpendicular directions.

Conclusions

1. As a result of the test the fundamental possibility of the application of salt lubricants for continuous hot rolling of tubes

was confirmed.

2. The best properties are possessed by the lubricant with the following composition: 40% zinc chloride, 30% potassium chloride, 30% sodium chloride, 10% (of the weight of the salts) magnesium oxide and 45% (of the salts and filler) water.

3. During rolling of tubes of steel 1Kh18N9T with lubricant No. 6 the rolling of the metal on the mandrel proceeded satisfactorily. The peak loads on the motor of the continuous mill were increased on the average, by 4.5% (within permissible limits) as compared to the case with graphite-mazut lubricant. Extraction of mandrels was accompanied by strong vibration.

No intercrystallite corrosion was detected on tubes after rolling with lubricant No. 6.

The quality of the tubes in terms of the geometry of the external and internal surfaces (after pickling) was satisfactory.

The pickling time for tubes rolled with a salt lubricant decreases twice as compared to that of tubes rolled with graphite-mazut lubricant.

4. Rolling of carbonic [carbide?] tubes with lubricant No. 6 proceeded satisfactorily. The peak loads on the motor of the continuous mill were increased insignificantly (on the average, by 4%) as compared the case with graphite-mazut lubricant. The rolling of metal on the mandrel and withdrawal proceeded analogously to those in rolling during work with graphite-mazut lubricant.

The quality of tubes in terms of the geometry of the external and internal surfaces (after pickling) is satisfactory.

5. It was found that a salt lubricant remaining on the internal surface of tubes promotes general corrosion of the metal of the tubes. However, on tubes of steel of brand 1Kh18N9T, once past the stage of

pickling, there is no corrosion.

6. An insignificant emission of smoke was observed during rolling with all the experimental lubricants.

7. The influence of the quantity of the various fillers and components of the lubricant on the melting and crystallization temperatures, and also the influence of the quantity of diluent on the consistency of the lubricant (determining the covering ability per unit of surface of the mandrel), were established.

Literature

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